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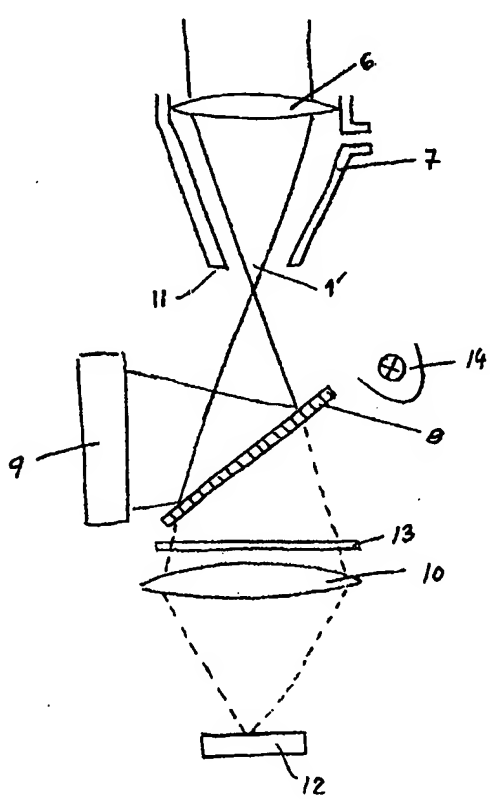
(54) Title: MEANS FOR VISUALIZING THE LASER BEAM IN A LASER MACHINING SYSTEM



(57) Abstract: Means for visualizing the laser beam (1') in an aperture, for instance the nozzle opening, in a laser machining system, for instance in a laser cutting device, and in which system the laser beam is transmitted from a laser source (1) to the workpiece (3) to be processed and wherein a nozzle (7) is arranged coaxially with the laser beam (1') to deliver an assisting gas. The visualizing means comprises an equipment (10, 12), in the form of an optical image system to make an image of the laser beam (1') and/or the aperture (11).

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Means for visualizing the laser beam in a laser machining system

The present invention relates to means for visualizing the laser beam in an aperture, for instance the nozzle opening, in a laser machining system, for instance in a laser cutting device.

Generally, the invention relates to a visualization of the laser beam in an aperture such as the nozzle opening in a laser machining system, but specifically in a laser cutting device in which a very accurate centering of the laser beam is required. Therefore, the invention will be described in connection with a laser cutting device, but it is not limited to such a device. It can also be used in other types of laser machining systems, such as in welding machines or the like.

In a laser cutting device the laser beam is focused on a small area (spot), normally having a diameter of 0,1-0,5 mm, so that the high energy intensity can be used to process (vaporize) the workpiece material. Laser machining systems are frequently used for cutting, welding, surface processing and marking operations in the manufacturing industry. Today, laser cutting is more frequently used than welding. For uncomplicated products so-called x-y tables are used for cutting plane metal sheets or plates. For other products with more complicated geometries (for instance parts for the car manufacturing industry) 3D-laser machines are normally used. Thanks to the recent development of optical fibre technique such laser machining stations are designed with flexible transmission of the laser beam to the workpiece by means of optical fibres. In many cases a machining head is attached to the arm of an articulated robot for manipulating the laser beam relative to the workpiece. The transversal position (x- and y-directions) as well as the vertical position, perpendicular to the workpiece surface (z-direction), is controlled by the

robot.

It has been a very rapid development with respect to Nd:YAG lasers during the last years, and this type of laser has become more and more popular compared to CO_2 lasers when it comes to 3D-laser cutting. The main reason for this is the fact that the Nd:YAG laser beam can be transferred to 6-axes industrial robots via flexible optical fibres. Both the Nd:YAG laser and the robot itself has been substantially improved during the last years which means increased demands also on the cutting tool. It must work more rapidly, it must sustain more power, it must be possible to reach and handle the tool even in a space with relatively small dimensions, the cable and hose wear must be minimized etc.

In a laser cutting device there is also an assisting gas delivered coaxially with the laser beam through the nozzle. The assisting gas could be an active gas for increasing the cutting efficiency, such as oxygen gas, or a passive gas used for removing melted metallic material from the cutting surface, such as nitrogen. In order to optimize the cutting result it is important that the laser beam is centered with respect to the nozzle opening.

Previously, it has been necessary to perform such an adjustment of the laser beam more or less manually, which is a laborious and time consuming operation. Typically, the nozzle opening was taped and then a hole was burned in the tape by the laser beam as an indication of the laser beam position. Then the laser beam was adjusted and the test repeated. Often the space available for such a procedure is limited and parts of the equipment has to be dismantled before the realignment of the beam. Such a procedure is not acceptable for instance in the car manufacturing industry.

The object of the present invention is to provide means

for adjusting the laser beam in a more simple way.

According to the invention a measuring equipment is arranged on the beam exit side to visualize the position of the laser beam and/or the nozzle opening.

According to a preferred embodiment the equipment is arranged after the nozzle opening, seen in the propagation direction of the laser beam, to make an image of the end surface of the nozzle and the laser beam in a corresponding plane.

In the following a preferred embodiment of the invention will be described more in detail with reference to the accompanying drawings, in which

figure 1 schematically illustrates an industrial robot with a laser cutting device, and

figure 2 illustrates the laser cutting device with an equipment according to the invention.

In figure 1 a fiber optical laser cutting system is illustrated. The laser beam is directed from a laser source 1, for instance a Nd:YAG laser, via an optical fiber 2 to the workpiece 3 in question. An industrial robot 4 is used for moving the laser head 5 of the system. The transversal position (x- and y-directions) as well as the vertical position, (z-direction), is controlled by the robot.

Thanks to the recent development of three-dimensional laser processing machines, welding and cutting of products with more complicated geometries have increased and will increase even more in the future. For this reason it is important that all parts in the laser processing machines are optimized. As already mentioned in the introductory portion of th specification, it is especially important in a laser cutting device that the laser beam is centered

in the nozzle opening during the entire cutting process.

In figure 2 a laser beam 1´ is focussed by means of a lens 6 or a mirror on the workpiece to be processed. Coaxially with the laser beam there is a nozzle 7 for the assisting gas. According to the invention there is also a measuring equipment arranged, in this case on the beam exit side, under the cutting nozzle, for visualizing the laser beam. The measuring equipment comprises a dielectric mirror 8 which is reflecting the main part of the laser power to an absorbing unit 9 which takes care of the main part of the power for cooling it away. Behind the dielectric mirror 8 an optical image system 10 has been arranged which system provides an image of the end surface 11 of the nozzle towards a camera which is sensitive to Nd:YAG laser radiation and visible light, for instance a CCD camera or the like 12. Both the end surface 11 of the nozzle and the laser beam 1´ is visualized by the camera in the corresponding plane, and a centering of the laser beam can easily be performed. The position of the laser beam in the nozzle opening can be observed while the beam is adjusted.

To make sure that the contrast between the end surface 11 of the nozzle and the laser beam 1´ is good enough it might be necessary to introduce another damping filter 13 for the laser beam and/or an auxiliary light source 14 to illuminate the nozzle opening and thereby improve the image of the end surface 11 of the nozzle.

By having this type of camera in the system to make an image of the nozzle opening and the beam, it also means that other measurements can be performed by using image processing techniques. Not only the position of the laser beam relative to the nozzle, but also the position of the nozzle and the laser beam itself relative to the measuring equipment can be determined. By knowing the fixed position of the measuring equipment, the spatial position of the nozzle and the beam can also be determined. By means of

such positional information, the position in the xy-plane is known. If the measuring equipment is moved relative to the nozzle and the beam along the axis of the beam the focus of the beam and the nozzle can be determined by using image processing techniques. In this way all positions, also in the z-direction, can be determined.

The invention is not limited to the example which has been described here but can be varied within the scope of the accompanying claims.

CLAIMS

1. Means for visualizing the laser beam in an aperture, for instance the nozzle opening, in a laser machining system, for instance in a laser cutting device, and in which system the laser beam is transmitted from a laser source (1) to the workpiece (3) to be processed and wherein a nozzle (7) is arranged coaxially with the laser beam (1´) to deliver an assisting gas, c h a r a c t e r i z e d by a measuring equipment (10, 12) arranged on the beam exit side to visualize the position of the laser beam (1´) in the aperture.

2. Means according to claim 1 c h a r a c t e r i z e d i n that the equipment is arranged after the nozzle (7), seen in the propagation direction of the laser beam, and comprising an optical image system (10, 12) to make an image of the aperture (11) and/or the laser beam (1´) in the corresponding plane.

3. Means according to claim 2 c h a r a c t e r i z e d i n that the optical image system comprises a camera which is sensitive to Nd:YAG laser radiation and visible light, for instance a CCD-camera.

4. Means according to claim 2 c h a r a c t e r i z e d by a dielectric mirror (8) arranged in front of the image system (10, 12) for deviating the main part of the power of the laser beam to an absorbing unit (10).

5. Means according to claim 2 c h a r a c t e r i z e d by a damping filter (13) for the laser beam (1´) to improve the contrast between the aperture (11) and the laser beam (1´) for the image system (10, 12).

6. Means according to claim 2 c h a r a c t e r i z d by an auxiliary light source (14) directed towards the

aperture (11) in order to improve the image of the aperture (11) for the image system (10, 12).

7. Means according to claim 3 c h a r a c t e r i z e d i n that the image generated by the image system (10, 12) is processed for determining position and sharpness (focus) for the nozzle (7) and/or the laser beam (1´).

8. Means according to claim 7 c h a r a c t e r i z e d i n that the image system (10, 12) is movable in order to determine the position of the focus of the laser beam.

Fig.1

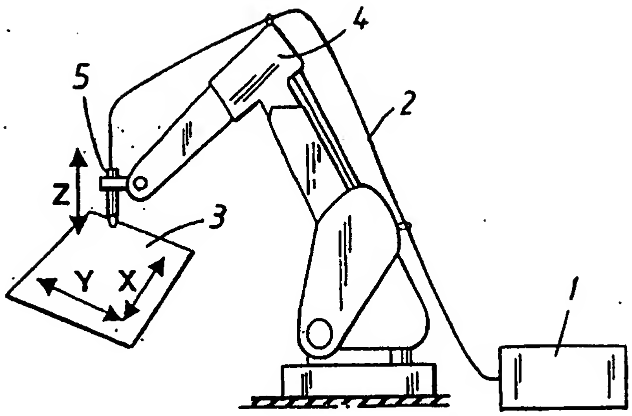
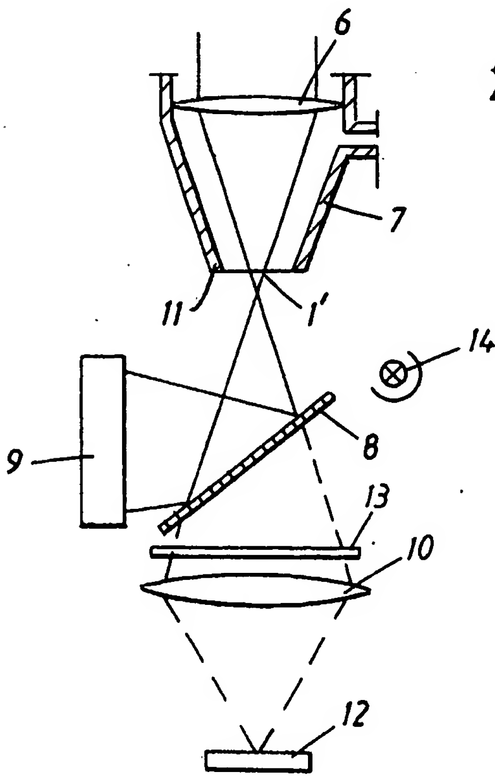


Fig.2



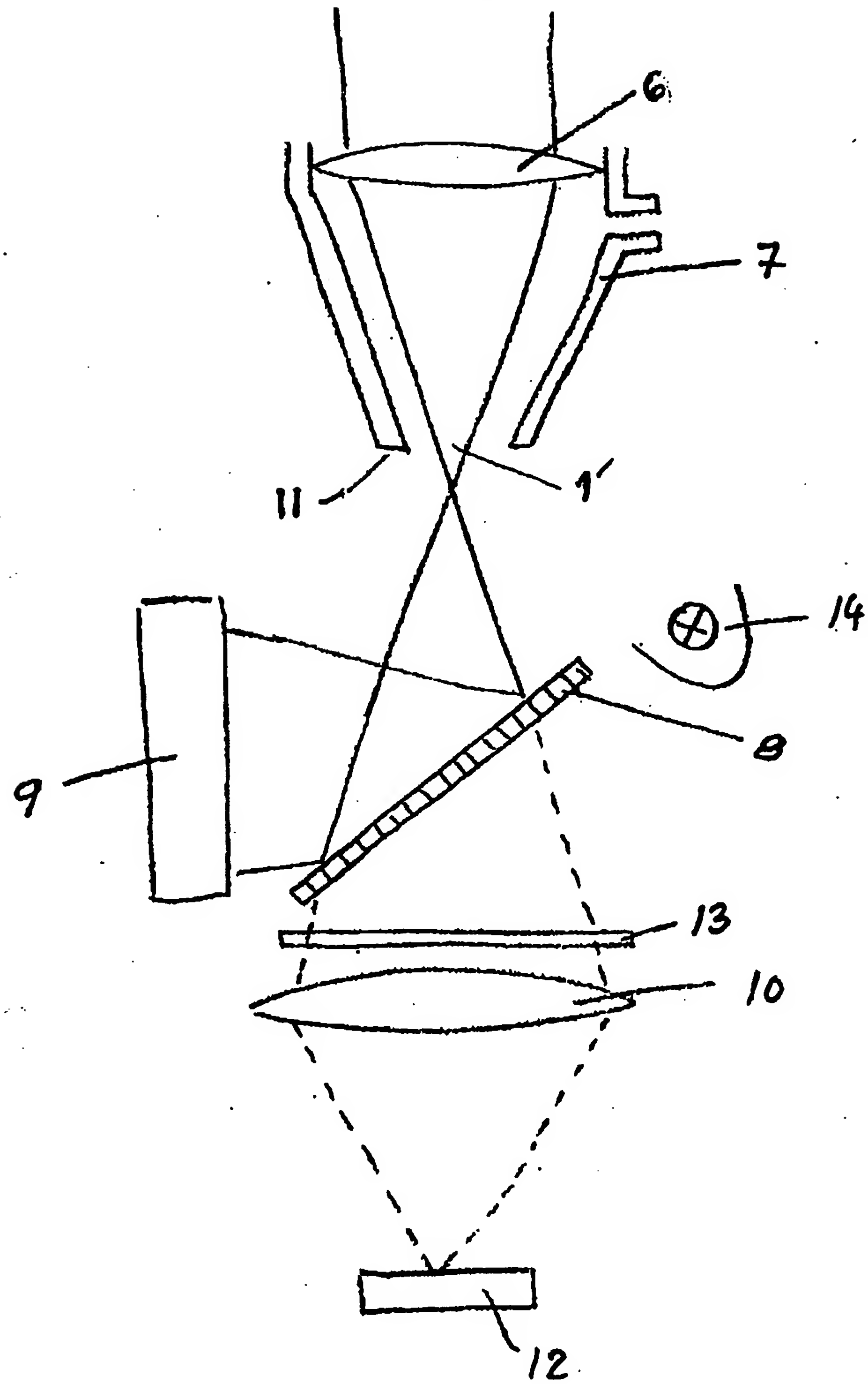


Fig. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 03/00037

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: B23K 26/04, B23K 26/42

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: B23K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4668088 A (QUINQUE, C. ET AL), 26 May 1987 (26.05.87), column 6, line 36 - column 7, line 35; column 7, line 44 - column 8, line 5, figure 1	1-8
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X	Patent Abstracts of Japan, abstract of JP 59-33092 A (MITSUBISHI DENKI K.K.), 22 February 1984 (22.02.84)	1
A		2-8
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A	US 4427873 A (ORITA, N. ET AL), 24 January 1984 (24.01.84), abstract	1-8
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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 April 2003	17-04-2003

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Patent Abstracts of Japan, abstract of JP 10-249566 A (AMADA CO LTD.), 22 Sept 1998 (22.09.98)	1-8
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A	WO 0054925 A1 (GSI LUMONICS), 21 Sept 2000 (21.09.00), abstract	1-8
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INTERNATIONAL SEARCH REPORT
Information on patent family members

29/03/03

International application No.
PCT/SE 03/00037

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